Section 212
Issue No. 3
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RINGING SYSTEMS

Purpose: This addendum adds Paragraph 5.3 and 8.2 to REA TE & CM-212, Issue No. 3, dated November 1970, to cover several situations which have developed since release of the basic document.

Additions: Add Paragraphs 5.3 through 5.33 and 8.2 through 8.23 to read as follows:

5.3 Bell Tapping During Dialing

5.31 When older type straight line ringers are used in the bridged configuration, or when modern straight line ringers, not listed as "long loop" devices, are used with elevated voltages, bell tapping during dialing may be encountered.

5.32 When the above situation is encountered, older ringers should be replaced with more modern design conforming to PE-47. Ringers used with loops in excess of 2000 ohms should be 20Hz tuned devices, listed as "long loop" ringers in the List of Materials.

5.33 As an interim measure, until the conversion mentioned in Paragraph 5.32 can be accomplished, the problem may be reduced by connecting tapping ringers through the break contacts of the hook switch. This arrangement removes the dialing telephone's ringer from the circuit during the dialing operation. This conversion does not, however, provide any relief for extension sets on the same line.

8.2 When several extension telephones, with ringers connected, are placed on long loops, providing sufficient power to ring all ringers may be a problem.

8.21 At ringing frequencies, modern two gong ringers generally are of higher impedance than miniature, single gong units. As a result more two gong ringers can be operated over a given loop than single gong units.

8.22 When one and two gong ringers are mixed on a long loop, more electrical power will be required to provide an adequate ring than if only two gong ringers were used. As a result, if difficulties of this type are encountered, use of two gong ringers in place of single gong units should be attempted.

8.23 In the event that more extension ringers are desired than can be rung over a given loop, a ring-up relay can be used as described in Paragraph 5.23.

RINGING SYSTEMS

CONTENTS

1. GENERAL

1.1 This section provides REA borrowers, consulting engineers, and other interested parties with information for use in the design, construction, and operation of REA borrowers' telephone systems. It replaces Issue No. 2, November 1965; Addendum No. 1, April 1966; and Addendum No. 2, December 1969.

1.2 This section updates information on the use of ringing equipment and provides the latest guidelines for ringing system design. The principal changes include:

1.21 Greater emphasis and detail on the use of straight-line biased ringers for certain applications.

1.22 Introduction of the Grounded Unlike Ringing Frequencies (GURF) mode of ringing.

1.23 Expansion and updating of material on long loop ringing.

1.24 A discussion of "special" ringing problems.

1.25 Changing from divided straight-line ringing for two-party lines to bridged 20- and 30-cycle tuned ringing.

1.26 Introduction of ringing load splitting.

1.27 Recommendation that vibrator ringing generators be replaced.

1.3 The term "ringing system" as used herein refers to an electrical power source (generator) having one or more output voltages and frequencies which when applied over a suitable circuit to one or more suitable electro-acoustic transducers (ringers) produces an audible sound to attract a person to answer a telephone. Ringing generators are normally furnished as part of the central office equipment (COE) and ringers are usually purchased as part of an order for telephone sets, frequently from a different manufacturer than the manufacturer of the central office equipment. This section stresses the system aspects of ringing so that the system design Engineer will understand how the separately purchased components must work together as a system.

1.4 The principal types of ringing systems discussed and recommended herein are one party bridged ringing systems, and two- and four-party bridged tuned ringing systems, for use on voice frequency loops. Except where specific references are made to carrier systems, it should be assumed that the material herein applies only to voice frequency loops.

1.5 Other ringing systems and techniques which are recommended for use in special situations are also discussed. These include 8-party divided multifrequency, four-party GURF ringing, long loop ringing techniques, and ringing considerations when subscriber carrier systems are used.

1.6 Superimposed ringing systems are not recommended for new installations, but existing systems may be retained for four-party full selective service in exchanges which have only short loops. Superimposed ringing should not be used on loops exceeding 2000 ohms resistance.

1.7 "Divided ringing" which means that the ringers on each line are connected from either line conductor to ground, is the most advantageous method of ringing from ringability, selectivity, and as a means of preventing bell tapping during dialing. It is required with certain types of Automatic Number Identification (ANI) systems. Divided ringing is also advantageous from maintenance considerations because it makes it possible to ring a station in the "off hook" condition, and is in effect a built-in open-ground alarm device. Therefore, from strictly ringing considerations, divided ringing would usually be preferable to bridged ringing. However, because of noise considerations and, under some conditions, because of cross ringing, bridged ringing is recommended in most applications in the following paragraphs. A recent Bell System study indicates that on the average, it is reasonable to expect a 10 Db improvement in balance with bridged ringing, as compared with divided ringing. If ringing problems occur with bridged ringing, it may be possible to correct them by changing to divided or GURF ringing, provided that the increased susceptiveness that usually occurs when ringers are connected to ground does not result in an unacceptable noise level. This recommendation for bridged ringing means that ANI systems which utilize either a ringer winding or a special inductor connected from line to ground during the talking condition are not recommended.

1.8 Specially designed and tested ringers are required to insure adequate ringing on long cable loops. In this section, long cable loops are defined as cable loops having dc resistances ranging from 2000 to 4300 ohms. Further discussion of long loop ringing is included in paragraphs 3.8 and 3.9.

2. RINGERS

2.1 The most common form of ringer is an electro-mechanical transducer which has a permanent magnet in a magnetic circuit consisting of a frame, core, magnetic shunt, and pivoted armature in an air gap. The flux through the magnetic circuit is alternately increased and decreased when ac ringing voltage is applied to a coil (or coils) surrounding the core, causing the armature to turn on its pivot, and a clapper attached to the armature to strike a gong (or gongs).

2.11 Straight-Line Biased Ringers - The straight-line biased ringer is one which is designed to be reasonably sensitive to the magnitude of the applied voltage and insensitive to the frequency of the applied voltage. It relies on a biasing spring to suppress its response to spurious voltages. The big advantage of straight-line biased ringers over other types of ringers is universality. That is, one basic ringer will be used in a majority of telephone sets rather than having four different ringers as with a multifrequency system. In properly designed one party systems, all telephones can be equipped with the identical type of ringer except for a few specialty telephones. Because the sound output of a straight-line ringer is not affected by minor frequency drifts of the ringing generator, neither the frequency stability of the generator nor the adjustment of ringers is critical. Most makes of straight-line ringers are also less expensive than other types of ringers. The disadvantages of straight-line ringers are: (1) More susceptible to bell tapping during dialing when connected bridged, and (2) more susceptible to bell tapping on lightning surges when connected divided. A biasing spring is provided to control these spurious responses but increased bias spring tension reduces the ringing range, so that a heavily biased straight-line ringer has less ringing range than a 20 Hz tuned ringer.

2.12 Tuned Ringers - Tuned ringers are designed so that the resonant frequency of the mechanical moving system is the same as the frequency of one of the voltage outputs of a ringing generator. The electrical constants of the ringer are also adjusted so that the electrical resonant frequency of each ringer approximates its mechanical resonant frequency. This results in a ringer that is very sensitive to a certain frequency and very insensitive to all other frequencies. Tuned ringers have the advantages of greater ringing ranges and less sensitivity to spurious voltages than other types of ringers, provided the ringer adjustments are accurately set and maintained, and provided the ringing generator frequencies are stable and accurately set. The principal disadvantages of tuned ringers are that (1) their adjustment is critical and is more difficult to set and

to maintain, and (2) that a ringer tuned to a different frequency is required for each party on a bridged multiparty line. These same disadvantages apply also on multiparty divided ringing lines except that ringers of the same frequency can be assigned to two parties on a line. These complicate ringer maintenance, stocking, and inventories. Each different resonant frequency used for the ringers requires both a primary and a standby ringing generator output of this same frequency. Multifrequency ringing generators are substantially more costly and occupy more space than equivalent single frequency generators. A minor disadvantage of tuned ringers is that the quality of the output sound of each is different for each different frequency.

2.13 When used at main stations, straight-line and tuned ringers should have a sound output of at least 75 dB rap. at a distance of one meter. (DB rap means dB above Reference Acoustic Pressure. Zero dB rap = 0.0002 dynes/cm^2.) An adequate sound output under specified conditions is one of the criteria used to determine the acceptability of a ringer for listing on our "List of Materials Acceptable for Use on Telephone Systems of REA Borrowers." Miniaturized sets are usually equipped with single gong ringers to conserve space, but their sound output is not usually as great as that of two-gong ringers. Because of this, most single gong ringers on our List of Materials are acceptable <u>only as extension ringers</u>.

2.2 Loud Ringing Ringers - Where a greater than normal sound output is required, such as in noisy locations or outdoor locations, "loud ringing bells" are available in both straight-line and tuned types. These ringers usually have the same basic ringer mechanism as a standard two-gong ringer intended for mounting in a telephone set, but are equipped with larger gongs and a weather resistant housing. They have substantially the same impedance, therefore, draw the same power as a standard ringer, and have approximately the same ringing range as a standard ringer.

2.3 Tone Ringers - Tone ringers are basically electro-acoustical transducers, which operate from ringing voltage. The applied voltage is converted into electrical voice frequency tones by solid state circuitry, and the transducer (which in most designs is a modified telephone receiver unit) converts the electrical frequencies into acoustic output. No frequency selective tone ringers have been developed to date, so tone ringing is not yet practical for multiparty systems. Tone ringers have been available for a number of years but because they are much more expensive than conventional ringers they have been used very little by operating telephone companies. Tone ringers can be designed to operate from relatively low voltage such as 400 Hz ringback tone. It is anticipated that the next generation of telephone sets will have this type of ringer. The 400-cycle tone ringers would have the advantage of being able to use voice frequency repeaters to extend ringing ranges. Tone actuated ringers have been available in station carrier equipment for a number of years.

2.4 Auxiliary Ringing Devices - Various types of auxiliary audible signals, visual signals, ring-up relays, etc., are available for a variety of applications. Virtually all of these devices will operate from 20 Hz ringing voltage, but only a few of them are designed to respond to other ringing frequencies.

3. PREFERRED RINGING SYSTEM DESIGNS

3.1 The preferred ringing system designs are generally applicable to exchanges having buried cable loops of up to 4300 ohms resistance. Ringing systems should be designed to provide fully selective ringing to all subscribers. Bridged ringing is the preferred standard for all lines except eight-party lines in order to minimize noise. Divided ringing should be used on eight-party lines with ringers assigned evenly on each side of the line to the extent practicable in order to electrically balance the line. When odd line fills cause excessive noise, a dummy ringer should be added as described in paragraphs 4.12 and 4.121. Combinations of bridged and divided ringers on the same line should not be used because this invites cross-ringing. Where projects are being upgraded, the new ringing system design should make the maximum practical use of existing equipment which still appears on the List of Materials to avoid its premature retirement.

3.2 The principal characteristics of preferred ringing systems for voice frequency loops are summarized in Table 1. Additional details are given in the following paragraphs.

3.3 The preferred one party ringing system consists principally of a dc powered 20 Hz primary ringing generator and an equivalent standby, dual interrupters, and a bridged straight-line biased ringer in each telephone set on voice frequency loops whose resistance does not exceed 2000 ohms. A 20 Hz tuned ringer should be used in each set on voice frequency loops exceeding 2000 ohms resistance instead of a straight-line ringer. This type of exchange is likely to result only when all telephone sets are being replaced. The 2000-ohm limitation does not apply to some carrier systems.

3.4 The preferred ringing system for one and two-party exchanges is bridged straight-line biased ringers for one party lines up to 2000-ohm loops, bridged 20 Hz tuned long loop ringers for all telephones on one party loops exceeding 2000 ohms; and bridged 20 and 30 Hz tuned ringers for all two-party lines. Central office equipment for this system consists primarily of two sets of dc powered electronic 20 and 30 Hz ringing generators and dual interrupters.

TABLE 1

Preferred Ringing Methods

Parties Per Line	Type Ringers		Connection Mode			NOTES
	Tuned	Straight Line	Bridged	Divided	GURF	
1		X	X			For loops up to 2000 ohms resistance
	20 Hz		X			For long cable loops
2	X		X			Use tuned 20 Hz and 30 Hz ringers and ringing generators
4	X		X			
	X				X	GURF is preferred only if weak rings occur with bridged ringers
8	X			X		

3.5 The preferred ringing system for one, two-, and four- or one- and four-party exchanges is bridged straight-line ringers on one party lines up to 2000 ohm loops, bridged tuned long loop 20 Hz ringers on one party loops exceeding 2000 ohms; bridged 20 and 30 Hz ringers on all two-party lines; and bridged 20, 30, 40, and 50 Hz tuned ringers on four-party lines.

3.6 Specific recommended actions are as follows:

3.61 Conversion of existing eight-party multifrequency ringing to four-party.

a. Reconnect all ringers for bridged ringing.

b. Retain existing ringers except 60, 66, and 66-2/3 Hz ringers, if in good condition and still listed on the List of Materials.

c. Retain existing ringing generators if suitable (see paragraph 7.01).

d. Discontinue the use of 60 Hz or high frequency ringing generators.

e. Rework ringing circuitry of the switchboard and interrupters to provide only four ringing periods of 1.25-1.40 seconds each.

3.62 Conversion of existing multiparty multifrequency ringing to one party ringing.

a. Retain existing ringers except 60, 66, and 66-2/3 Hz, if suitable (see paragraph 3.61b).

b. Reconnect all ringers bridged.

c. Retain existing ringing generators if suitable (see paragraph 7.).

d. Ring using four-frequency ringing generators (see paragraph 7.023).

e. Rework ringing circuitry of the switchboard and interrupters to provide only four ringing periods of 1.25-1.40 seconds each.

f. Discontinue ordering tuned ringers except "long loop" 20 Hz tuned ringers for long loops.

g. Order straight line biased ringers for all additions and replacements except as stated in f. above.

h. Provide enough additional 20 Hz ringing capacity to eventually ring the entire office on the 20 Hz ringing generator. (See paragraphs 7.02, 7.022, 7.023, and 7.03 through 7.10.)

3.63 Conversion of superimposed or coded ringing to single-party ringing.

a. Retain existing ringing generators and ringers if suitable. (See paragraphs 3.61b. and 7.01.)

b. Remove and discard superimposing bias supplies and cold cathode tubes from the telephone sets.

c. Ring, using a single-frequency, 20 Hz ringing generator.

d. Connect ringers bridged.

3.64 All new equipment for one-party ringing.

a. Ring with single frequency, 20 Hz ringing generator.

b. Use bridged straight-line ringers, on loops up to 2000 ohms resistance.

c. Use 20 Hz tuned ringers on loops exceeding 2000 ohms resistance.

3.65 New equipment for two-party ringing.

a. Ring with 20 and 30 Hz ringing generators.

b. Use bridged 20 and 30 Hz tuned ringers.

3.66 New Equipment for four-party ringing.

a. Ring with four frequencies, do not use 60 Hz or above.

b. Use bridged tuned ringers.

3.7 Ringing Limits

3.71 Actual ringing limits vary with ringing frequency, number of ringers, method of connection, type and make of ringers connected on the line, the mutual capacitance and resistance of the cable pair, and the ringing voltage applied at the central office. All of these factors are too complex to be taken into account for each limiting condition. The ringing limits stated herein are for bridged ringing and allow a reasonable margin for manufacturing tolerances, aging of ringers, and deterioration of plant. They are based on "normal" ringing voltages of 105, 110, 115, and 125 volts r.m.s., respectively, for the four increasing frequencies of a series, (Harmonic, Synchromonic, or Decimonic), and on both laboratory and field tests. Basically, ringing limits for the higher ringing frequencies

are controlled by the mutual capacitance of the cable. Because the mutual capacitance of a cable varies linearly with the route length, a given number of miles 19-, 22-, or 24-gauge .083 mf cable has the same mutual capacitance but the resistance of each gauge is different. Divided ringing limits are substantially greater than the limits for bridged ringing.

3.8 Ringers which are listed as "Long Loop" ringers on page "rb" of the List of Materials are required to ring on loops ranging from 2000 to 4300 ohms of cable. Long loop ringers have been tested and have been found to provide satisfactory ringing when bridged on the loops described in paragraph 3.9. Long loop ringers are not required to perform satisfactorily on loops less than 2000 ohms resistance but many of them actually are satisfactory on loops ranging from 0 to 4300 ohms resistance. The List of Materials now includes only tuned long loop ringers. Bridged tuned ringers are preferred for 1, 2-, and 4-party service on long cable loops because they have greater margins of ringability, and are less likely to tap during dialing than are straight-line ringers. The greater the number of ringers installed per line the more difficult it becomes to provide satisfactory ringing.

3.9 The standard long loop ringing design limit for bridged multiparty lines (2- and 4-party) is 4300 ohms* D66 loaded all 24-gauge cable (15 miles); 3800 ohms of all 22-gauge cable (22 miles); or 3000 ohms of all 19-gauge cable (33 miles) when not more than six ringers are used per line. For single party lines the long loop bridged ringing design limit is 4800 ohms* of 24-gauge (17 miles), 4300 ohms of 22-gauge (24 miles), or 3600 ohms (39 miles) of 19-gauge cable with three bridged 20 Hz ringers. With one bridged 20 Hz tuned ringer the limit is 3900 ohms (42 miles) of 19-gauge cable. All of these limits are based on ringability only. They do not cover ring trip or transmission limits.

3.91 The ringing limits for mixed gauge loops can be determined with the aid of Figure 1 for 6 bridged tuned ringers, and Figure 2 for three bridged tuned 20 Hz ringers. Construction lines drawn parallel to each facility, out to the limit line, can be used to determine the limit for any make-up of cable loop. For example, in Figure 1, construction line #1 shows that a loop consisting of 1700 ohms of 24-gauge, and 2300 ohms of 22-gauge would have a ringing limit of 4000 ohms, and a length of 102 kF. If subscribers are located beyond 102 kF, it would be necessary to replace some of the 22-gauge cable with 19-gauge. The loop could be extended to 118 kF by reducing the 22-gauge cable to 1300 ohms and adding 750 ohms of 19-gauge as indicated by construction line #2.

*Because of other considerations, 2- and 4-party loop designs are limited to 3800 ohms, and single party loop designs are limited to 4300 ohms.

4. OTHER RINGING SYSTEMS

4.1 Divided four frequency ringing is recommended for all eight-party lines in order to obtain full selective ringing. The four lowest frequencies of the decimonic series are preferred. The 60, 66, and 66-2/3 Hz frequencies should not be used.

4.11 The decimonic series of frequencies 20, 30, 40, and 50 Hz is preferred unless the system is already committed to one of the other series. If the synchromonic series is used, the lowest frequency should be 20 Hz.

4.12 As indicated in paragraph 1.7, the connection of ringers from line to ground is objectionable because of noise considerations. Where the use of divided ringers is necessary (as on eight-party lines) the normal assignment of subscribers may result in a different number and tuning frequency of ringers connected on one side of the line than on the other side of the line. If such an occurrence results in objectionable noise with a one ringer unbalance, a dummy ringer should be connected from the other side of the line to ground at the odd subscriber's location to improve the balance of the line to ground. If because of extension ringers a greater than one ringer unbalance results, subscribers should be reassigned to different sides of the line as necessary to reduce the unbalance to not more than one ringer, then a dummy ringer should be added at the odd ringer location.

4.121 A dummy ringer must be of the same frequency and type as the ringer it is to balance. Its gongs must be removed, and it should be mounted in the basement or other protected (from the weather) inconspicuous location close to the station protector. If a sufficiently inconspicuous location cannot be found, the ringer must be mounted in a suitable enclosure.

4.2 "GURF" Ringing System

4.21 "GURF" is an acronym meaning "grounded unlike ringing frequencies." This system is a special type of divided ringing for 4-party lines which retains the ringability advantage, but avoids the cross ringing problem of regular divided ringing. On long cable loops, cable capacitance and voice frequency repeaters shunt some of the ringing energy to the opposite side of the line. This reduces the energy available to ring the ringer that is intended to be rung and causes a cross-ringing voltage to appear across the ringers connected between the other side of the line and ground. When there is a ringer on the nonringing side of the same frequency as that being applied to the side which is intended to be rung, cross-ringing is likely to occur. "GURF" is limited to four parties per line but utilizes four ringing frequencies so that cross-ringing energy at any applied ringing frequency does not find any ringer tuned to that frequency on the nonringing side of the line. A typical "GURF" application to a four-party

line would be the assignement of 20 and 50 Hz ringers to "tip" parties and the assignment of 30 and 40 Hz ringers to "ring" parties. This arrangement would be slightly poorer from noise considerations than would a regular divided connection which employed 20 and 30 Hz ringers on each side of the line.

4.22 "GURF" ringing is recommended on long four-party cable circuits if weak ringing is experienced with bridged ringing, provided the change from bridged to "GURF" does not produce excessive noise.

4.3 Warning - Bridged Tap Isolators are not compatible with grounded ringers.

4.4 Station Carrier Ringing Systems

4.41 All station carrier systems presently available regenerate ringing signals at the subscriber terminal. The regenerated ringing signals need only be transmitted over the relatively short voice frequency portion of the circuit beyond the subscriber carrier terminal. Because of this all subscribers served by carrier are considered to be on short loops insofar as ringing is concerned. Satisfactory ringing should, therefore, not be a problem regardless of cable makeup or loop length if the carrier systems are operating within their prescribed transmission limits. A summary of station carrier ringing systems presently available is as follows:

4.42 Multiparty Carrier Ringing Systems

4.421 On some systems the carrier subscriber terminal regenerates the same frequency at nearly the same voltage as fed into the central office terminal. Using standard tuned ringers, systems of this type offer up to five-party fully selective ringing on a bridged basis, or up to ten-party fully selective divided ringing.

4.422 One system superimposes voice frequency marker tones on the outputs of each ringing generator at the central office. A frequency selective tone detector, at the subscriber station, activates a standard straight-line biased ringer upon receipt of the proper marker tone. Five-party fully selective ringing is possible with this system, even though standard straight-line biased ringers are used.

4.43 Single Party Carrier Ringing System

4.431 Most station carrier equipment designed for single party service utilizes standard straight-line biased ringers. The central office terminal accepts standard ringing signals which are reproduced at the subscriber terminal.

4.432 One exception to the above is a system where the entire subscriber carrier terminal is built into the telephone set. This system accepts any ringing frequency at the central office, but alerts the subscriber by a built-in tone ringer.

4.44 Specific information on carrier system ringing should be obtained from the instruction manual of the particular carrier system involved.

5. SPECIAL SITUATIONS

5.1 Predominantly long open wire circuits

5.11 Ringing limits on predominantly open wire circuits are controlled more by leakage than by resistance or capacitance. With high leakage resistance (approaching infinity) the ringing mileage limit for open wire would be several times greater than that for cable plant. However, from practical design considerations, the open wire ringing limit must be predicated on the relatively low leakage resistance of open wire plant that can occur under wet conditions. This reduces the open wire ringing limit to about 50 miles.

5.2 Cable Loops Exceeding the Limitations of Paragraph 3.9.

5.21 Use "GURF" with not more than six ringers on two- or four-party lines.

5.22 On one party lines without extension ringers, use divided ringing with a tuned ringer connected through break contacts of the hook switch. This arrangement provides the greater ringing range of divided ringing, but avoids the noise problem by removing the ringer from the circuit when the handset is "off hook."

5.23 On one party lines with one or more extension ringers, use 60 Hz tuned ringers connected through the contacts of a ring-up relay to apply 110 volts 60 Hz commercial power to the ringers when 20 Hz ringing voltage is applied to the line. With this arrangement, ringing range depends only on the sensitivity of the bridged relay. Sufficient energy must be supplied over the loop to actuate the relay armature and contacts. The number of ringers that can be rung at a station with this arrangement is limited only by the 60 Hz current rating of the relay contacts.

6. CENTRAL OFFICE RINGING EQUIPMENT

6.1 The functions of central office ringing equipment are to: (1) Provide sufficient ringing generator power of the proper frequency and voltage; (2) code the outputs into suitable ringing and silent periods and

apply them to the proper side of the called party's line; (3) provide ring-back tone to the calling party indicating that the called party's line is being rung; and (4) provide ring-trip (a change from the ringing condition to the talking condition) when the called party answers.

6.2 The equipment usually includes primary and standby ringing generators, interrupters, tone generators, ringing generator frequency meter and voltmeter (and in some instances, ballast lamps), along with central office equipment circuitry, such as standby transfer circuits, ringing relays, and minor and major alarms.

6.3 Ringing generators provide up to five stabilized ringing frequencies of sufficient power to carry the office ringing load. A standby ringing generator is provided for backup in case of failure of the primary equipment. A minor alarm occurs in case of primary ringing generator failure, and a major alarm occurs in cases where both primary and standby units fail. A transfer circuit is provided to automatically transfer the ringing generator load to the standby when failure of a primary generator occurs.

6.4 Ringback tone is provided by a tone oscillator that generates tones complying with DDD requirements.

6.5 The interrupter interrupts ringing generator voltage to the called party's line and ringback tone to the calling party's line (except on some revertive calls) to produce a silent period during the ringing cycle. Experience has shown that the duration of the ring is an important factor in obtaining satisfactory ringing, especially on long loops. It takes a short but finite time to charge the capacitance of the loop and for the clapper vibration to build up sufficient amplitude to strike the gongs. A short duration ring coupled with a relatively low sound output caused by reduced voltage across the ringer on long loops can result in subscriber complaints. To prevent this situation interrupter cycles should provide two-second ringing periods with single frequency ringing, and <u>not less than 1.25 second ringing periods in a 6-second cycle with four-frequency ringing.</u> Five-frequency ringing requires either a longer cycle or shorter ringing period, therefore, should be avoided where practicable. In some switchboards the ringing load is split so that ringing power is available to only a portion of the connectors in a switchboard at any one time (taking advantage of the silent period). This reduces ringing power requirements, but is not normally furnished in switchboards having less than 2000-3000 connector terminals. A transfer circuit is provided to automatically transfer from the regular to the standby interrupter if the regular interrupter fails.

7. RINGING GENERATOR EQUIPMENT

7.01 Ringing generators selected from the List of Materials are required for all new installations. These generators comply with REA Specification PE-40. For conversions of existing systems, ringing generators complying with PE-40 and static magnetic types may be retained if in good

condition and suitable for the proposed system. All vibrators and other types of ringing generators should be replaced.

7.02 Ringing generator equipment purchased in conjunction with upgrading an exchange should normally be large enough to carry its anticipated part of the office load for a period of 15 years, provided this does not require single frequency generators larger than 50 watts capacity or multi-frequency generators larger than 25 watts per frequency. When ordering ringing generator equipment, the minimum power needed for each ringing frequency initially and for the 15-year requirement should be specified by the borrower or its engineer. It is not necessary for the power rating of each frequency generator to be the same. Power boosters that can be applied to any frequency are available with most types of solid state equipment. It is also practical to operate ringing generators in parallel, and to split the load in the interrupter and switchboard circuitry. These options provide the COE supplier with considerable flexibility that would enable him to meet the requirements in the most economical manner.

7.021 In single frequency exchanges where the initial requirements exceed 25 but are well below 50 watts and the 15-year requirements are well above 50 watts, a 50-watt generator (plus standby) should be purchased initially. When load growth makes the 50-watt generator inadequate the load should be split and further purchases of ringing generators should be deferred until this arrangement is no longer adequate.

7.022 In multifrequency exchanges, where the initial requirements exceed 15 watts per frequency, but are less than 25 watts, and the 15-year requirements are well above 25 watts per frequency, 25-watt generators (plus standbys) should be purchased initially. When load growth makes the 25-watt generators inadequate power boosters should be added to the overloaded generators.

7.023 Where multiparty, multifrequency ringing systems are being upgraded to one party, the fifth frequency (highest frequency) generator should be disconnected. The resulting four frequency system can then be provided with a 6-second interrupter cycle having ringing periods with a minimum duration of 1.25 seconds. (See paragraph 6.5.)

7.0231 Solid state ringing generators are usually capable of being tuned to any ringing frequency by simple strappings. Therefore, if the existing ringing generators are retunable, the fifth frequency (highest frequency) generator should be disconnected, retuned to 20 Hz, then reconnected in parallel with the existing 20 Hz generator when needed. It is not practicable to do this with other types of ringing generators.

7.03 The minimum size of 20 Hz ringing generators recommended for single frequency exchanges is 25 watts. Fifteen-watt generators should not be used.

7.04 In sizing 20 Hz ringing generators for exchanges being upgraded from multiparty to one party, it should be kept in mind that paragraph 3.62(f) requires 20 Hz long loop tuned ringers on all loops exceeding 2000 ohms, and paragraph 3.62(g) states that straight-line ringers should generally be ordered for all replacements and additions on shorter loops. This will gradually increase the load on the 20 Hz ringing generator, unless the upgrading involves conversion of a large number of voice frequency loops to carrier operation. If the upgrading includes conversion to pushbutton dialing, new telephone sets will normally be required. All of these new sets should be equipped with straight-line or 20 Hz long loop tuned ringers.

7.05 Power requirements for ringing generators should be based on the sizing criteria set forth in this section and should be specified by the borrower or the borrower's engineer. Ringing power specified should be adequate for the number and geographic distribution of ringers expected to be connected to the exchange by the end of the period under consideration. The 15-year number of ringers should be estimated to be 30 percent greater than the expected number of main stations.

7.06 The criteria for sizing CDO ringing plant are divided into three categories, based on the longest loop distance of any subscriber served on a voice frequency basis and the number of ringers, as determined in paragraph 7.05. Ringing generator loads per ringer for cable plant vary with calling rates, answer times, loop lengths, ringing frequency, number of ringers per line, and applied voltage. Because each of these factors can vary over wide limits it is difficult to accurately determine a realistic figure for the electrical load per ringer. Measurements of actual power required to ring specific makes and types of bridged ringers on specific loops have been made as a starting point. Values for the factors stated above have been developed empirically and have been applied to the measured power values to arrive at realistic, but conservative figures for design purposes on a "watts per ringer" basis. The resulting power per ringer figures shown in Table 2 have been determined in this manner. It is only necessary to determine whether subscriber distribution is within (a) zero to 10 route miles; (b) zero to 16 route miles; or (c) zero to 26 route miles. Then the normal CDO ringing power requirement per frequency can be determined from Table 2, based on the number of ringers. For example, an all one party 20 Hz exchange central office designed to serve (in 15 years) 1000 subscribers within 10 miles, and 300 between 10 and 16 miles, would be assumed to have 1000 + 300 + .30 (1300) = 1690 ringers within 16 miles of the CO. Table 2 shows a 50-watt 20 Hz ringing generator would be required. A second example would be an exchange having 200 one-party subscribers (with straight-line ringers) within 10 miles of the CO, 200 one party (with 20 Hz tuned ringers)

within 16 miles of the CO, and 1200 four-party subscribers within 16 miles of the CO, assigned equally among the 20, 30, 40, and 50 Hz frequencies. This exchange would be assumed to have:

200 + .30 (200) = 260 Straight-line ringers
200 + .30 (200) = 260 20 Hz long loop tuned ringers
300 + .30 (300) = 390 20 Hz tuned ringers
300 + .30 (300) = 390 30 Hz tuned ringers
300 + .30 (300) = 390 40 Hz tuned ringers
300 + .30 (300) = 390 50 Hz tuned ringers

From Table 2 the 260 straight-line ringers within 10 route miles of the CO and the 650 20 Hz tuned ringers within 16 route miles of the CO, could be served from the same 25-watt 20 Hz generator. The 30, 40, and 50 Hz ringers could be served from 25-watt 30, 40, and 50 Hz generators. In small multiparty exchanges 15-watt 20 Hz generators may be used if within the limits of Table 2, but a 15-watt generator should not be considered for a small single frequency exchange.

7.061 If in the above example some of the 50 Hz subscribers had been located more than 16 miles from the CO, the 390 50 Hz ringers would require a 50-watt generator, or a 25-watt generator with a 25-watt booster. In this instance the expected 10-year load should be determined. If the 10-year requirement could be handled by a 25-watt generator, it would probably be more economical to purchase 25-watt generators initially and add a power booster to the 50 Hz generator at a later date.

7.07 The sizing criteria for the three categories are shown below in Table 2. Table 2 assumes that the ringing load is not split. This is usually the case for switchboards of up to 2000-3000 lines. If the switchboard is arranged to provide ringing power to only a certain group or groups of the connectors during each ringing period (for example, to only 1/2 or 1/4 of the connectors) the power required would be reduced accordingly (to only 1/2 or 1/4 of that shown in the last column of Table 2).

7.08 Where the number of ringers exceeds the quantities shown in Table 2, the additional power required should be calculated using the appropriate watts per ringer as indicated in Table 2.

7.081 When office requirements reach 90% of the capacity of existing ringing generators, consideration should be given to the method of best increasing ringing power output. The maximum ringing loads should be determined by a number of measurements of actual power drain during busy hours of of the busy period of the year. The approximate power can be determined from two voltmeter measurements as indicated in Figure 3. An electronic voltmeter (VTVM) with a 0-3-volt scale should be used to accurately measure the voltage drop across the 1 ohm resistor. The tolerance of the 1 ohm resistor when hot should not exceed ± 5% of the nominal.

TABLE 2

RINGING POWER REQUIREMENT

(Bridged Ringers - All Cable Plant)

Ringer Frequency Assignment	0 - 10 Route Miles (a)		0 - 16 Route Miles (b)		0 - 26 Route Miles (c)		Power Requirements Per Frequency
Single Frequency Ringing Systems	Power per Ringer (Watts)	Maximum Number of Ringers	Power Ringer (Watts)	Maximum Number of Ringers	Power per Ringer (Watts)	Maximum Number of Ringers	(Watts)
Straight Line (20 Hz) and 20 Hz Tuned Ringers	.02	1250 2500 5000	.023	1090 2175 4350	.03	850 1700 3400	25 50 100*
Multifrequency Ringing Systems							
Tuned Ringers 16-2/3, 20 Hz	.02	750 1250 2500	.023	652 1090 2175	.03	500 850 1700	15 25 50
25, 30, 33-1/3 Hz	.033	455 757 1514	.040	375 625 1250	.05	300 500 1000	15 25 50
40, 42 Hz	.036	417 693 1386	.046	326 543 1086	.06	250 417 834	15 25 50
50, 54 Hz	.045	333 555 1110	.055	273 455 910	.075	200 333 667	15 25 50

*Use 50-watt generator and divide the load in the interrupter or ringing relays.

7.082 If the original generators are in good condition and comply with REA Specification PE-40, they should remain in service with new equipment supplementing rather than replacing them. In selecting new generators, careful consideration must be given to future growth potential of the office in addition to initial equipment costs; e.g., an office using 20 Hz single frequency ringing, with 1125 ringers assigned within 0-10 miles, might normally purchase a second 25-watt machine at this stage, or provide a 25-35-watt booster, extending capability to 2,500 ringers within 0-10 miles. No firm rule can be provided for selection of additional ringing generators. Each case should be judged on its merits.

7.09 The simultaneous ringing of a number of lines is sometimes required for fire or other alarm purposes. The power requirements for the simultaneous ringing of lines is shown for each ringing frequency on a per line basis in Table 3. The ringing load per frequency on each simultaneous ringing line should be added to determine the total power requirement per ringing frequency. The number and type of lines used for simultaneous ringing should be estimated, allowing for ample system growth. The power required for the simultaneous ringing of lines should be added to the normal CDO power requirement for ringing as determined from Table 2 to determine what size equipment should be ordered.

7.10 Power requirements should be specified on REA Form 558c - Part III, "Specifications, Detailed Central Office Equipment Requirements," in the 15-, 25-, or 50-watt sizes where practicable, for each ringing frequency needed in multifrequency ringing systems, and 25-, or 50-watt sizes for single frequency ringing systems. Where the 15-year power requirement exceeds 50 watts per frequency after making maximum use of load splitting, central office equipment suppliers should be requested to recommend the combination of units which are optimum for the anticipated growth of the system, and the borrower's choice should be incorporated in the central office equipment specifications.

8. MISCELLANEOUS CONSIDERATIONS

8.1 When an existing multiparty multifrequency T.P.S. exchange is upgraded to one party, paragraphs 3.62(f) and (g) recommend phasing-out tuned ringers (except for 20 Hz on long loops) in favor of 20 Hz straight-line ringers. In some instances of upgrades of this type the frequency marking leads have been tied together to simplify record keeping. This procedure is not recommended because it can result in serious ringing overloads, and would preclude the gradual change-over to straight-line (and 20 Hz tuned) ringers.

TABLE 3

SIMULTANEOUS RINGING-POWER REQUIREMENT PER LINE

(Bridged Ringers - All Cable Plant)

Ringing Frequency Assignment	Maximum Number of Ringers Per Line	Distance from CO (Miles)	Power Per Line (Watts)
16-2/3, 20	2	0-5 5-10	1.0 1.5
	6	0-5 5-10	1.5 2.0
	6	10-16 16-26	2.5 3.0
25, 30, 33-1/3	2	0-5 5-10	1.5 2.0
	6	0-5 5-10	2.0 2.5
	6	10-16 16-26	4.0 4.75
40, 42, 50, 54	6	0-5 5-10 10-16 16-26	3.5 4.4 6.1 8.0

8.2 A ringing generator frequency meter and voltmeter are required to be furnished by the central office equipment supplier. These meters may be portable units carried by the maintenance man or panel mounted units. The latter is preferred to maintain calibration of the instruments. They are used primarily for routine maintenance of the equipment. Voltmeters should be accurate to within ± 5% over the range of ringing frequencies involved. Frequency meters should be accurate to within ± 1/3 cycle. Reed-type frequency meters are recommended for systems using tuned ringers.

8.3 Ballast lamps provide a high source impedance, but cause poor ringing system voltage regulation. In the past, they were necessary with certain low internal impedance generators to prevent damage to the generator if it rang into a short circuit. Ballast lamps should <u>not</u> be used with PE-40 ringing generators which are self-protecting on overloads.

MAXIMUM CABLE RINGING LIMIT - SIX BRIDGED RINGERS

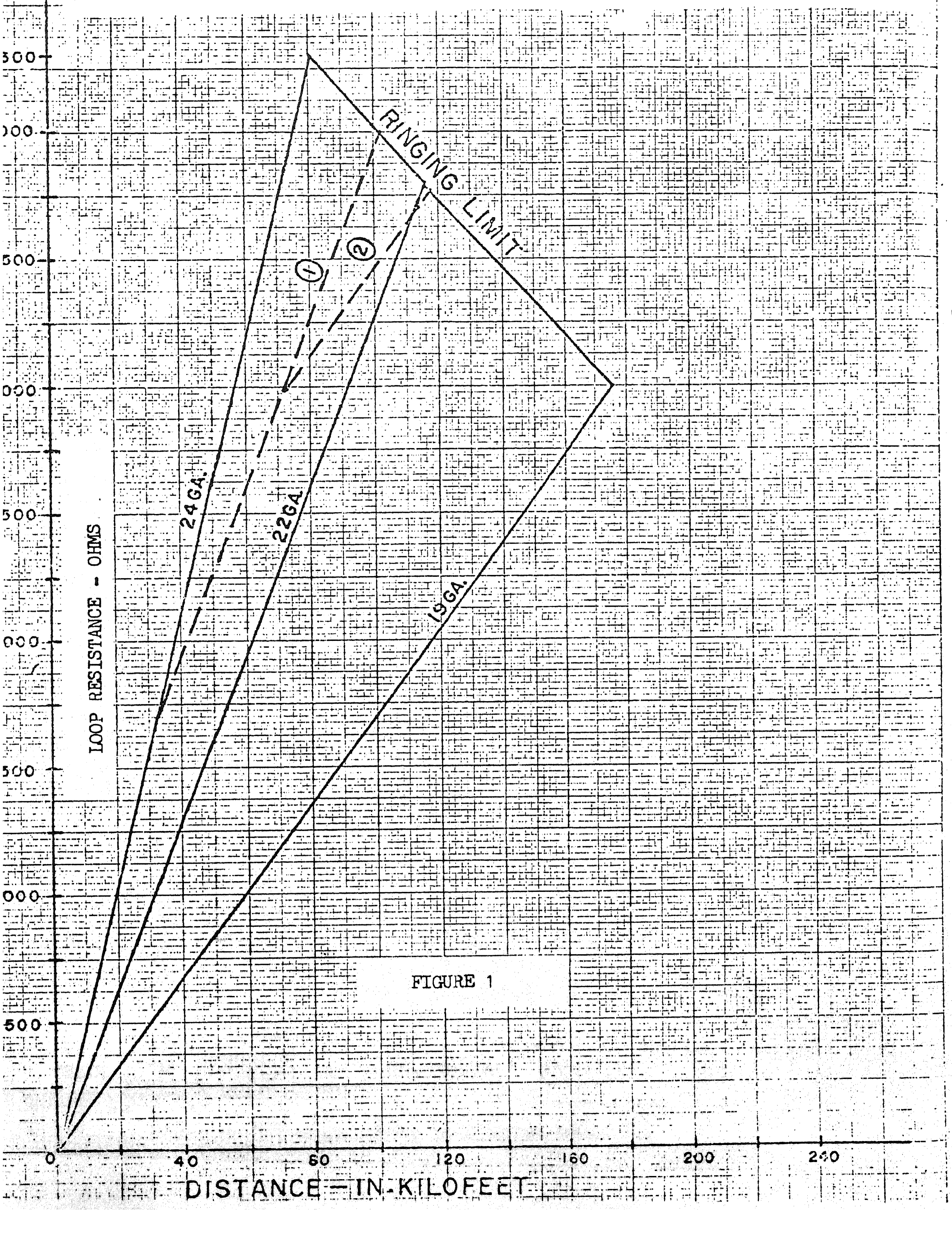


FIGURE 1

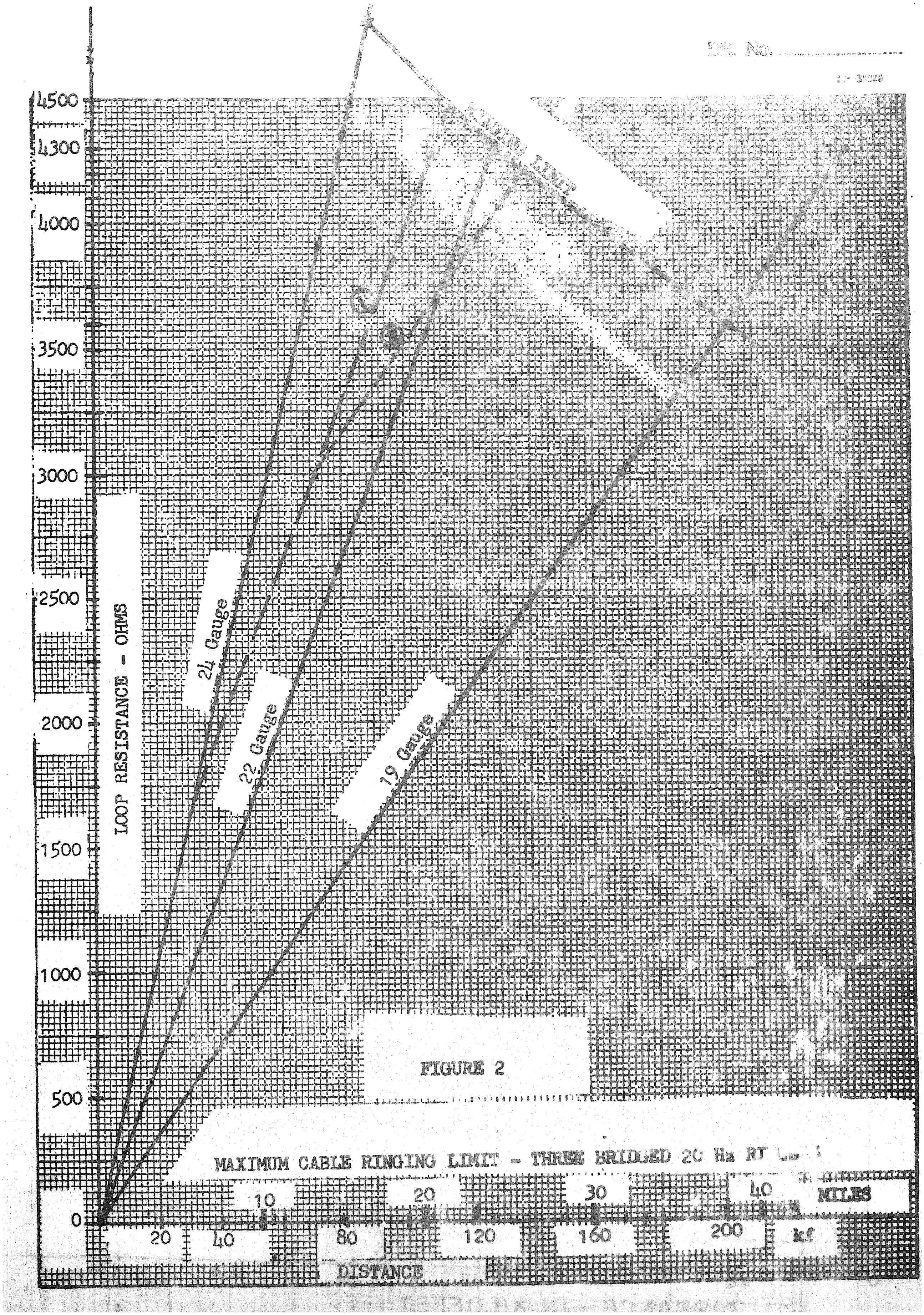
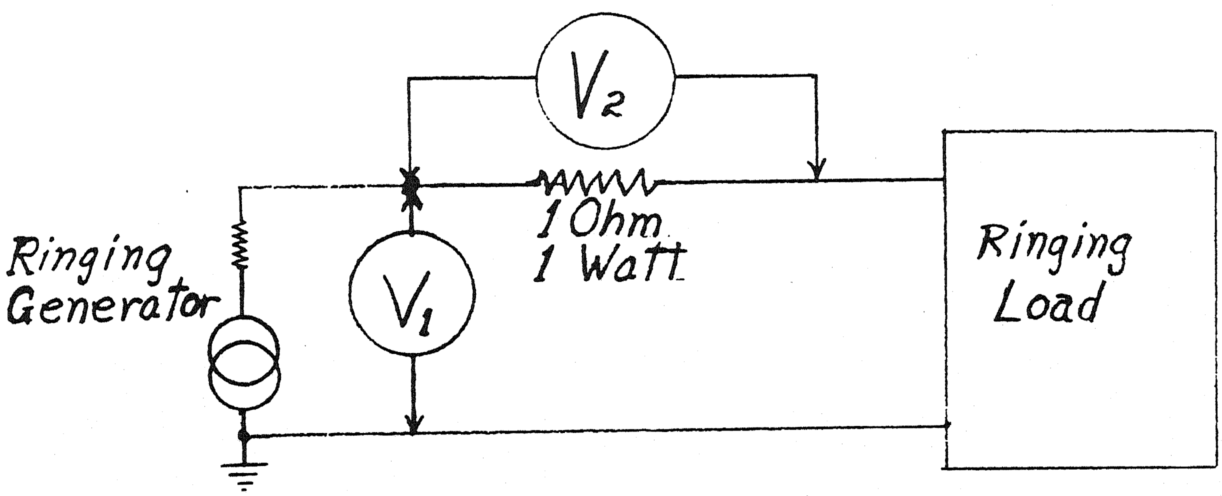

4500
4300
4000
3500
3000
2500
2000
1500
1000
500
0
LOOP RESISTANCE - OHMS
24 Gauge
22 Gauge
19 Gauge
MAXIMUM CABLE RINGING LIMIT - THREE BRIDGED 20 Hz
10
20
30
40
MILES
20
40
80
120
160
200
kf
DISTANCE

FIGURE 2



$$P_{Approx} = V_1 V_2$$

FIGURE 3

MEASUREMENT OF RINGING POWER